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ABSTRACT

The integration of concepts and contributions from learning theorists, media specialists, and teaching practitioners, optimized within a framework of selected system strategies derived from military management programs, can help resolve concerns for educational improvement and accountability and influence the utilization of technology enabling effective teaching and learning. This paper discusses relevant applications of technology and describes strategic systems, highlighting Program Evaluation and Review Technique (PERT), a management tool for project schedule monitoring and control. A systems framework for instructional design from Indiana's Ball State University also is presented. In 1970, Ball State used PERT when developing instructional materials, coupling it with Critical Path Method, a cost effectiveness tool. Needs assessment was the starting point. Instructional design was predicated upon written goals. Each instructional goal provided a benchmark for congruent evaluation and statistical analysis of achievement and a taxonomic index for the cognitive level of achievement as knowledge, comprehension, application, analysis, synthesis, and evaluation. The instructional materials were designed according to fundamental learning theory. Evaluation of Ball State's instructional design project was encouraging. Mean cognitive achievement at the level of knowledge was 79.2 percent, comprehension, 79.5 percent, and application, 62.9 percent. Mean ratings for relevance, practical value, and interest were 40.3 percent, 37.7 percent, and 33.3 percent, respectively at the very high level and 50.7 percent, 50.0 percent, and 45.7 percent, respectively, at the high level. (Contains 27 references.) (SM)

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SYSTEM-BASED STRATEGIES IN INSTRUCTIONAL DESIGN

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presentation made to the members of the board of the

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SYSTEM-BASED STRATEGIES IN INSTRUCTIONAL DESIGN

The integration of concepts and contributions over the last fifty years from three distinct sources, learning theorists, media specialists, and teaching practitioners optimized within a framework of selected system strategies derived from military management programs have the potential to notably resolve the concerns for educational improvement and accountability as well as influence the utilization of technology enabling effective teaching and efficient learning.

Introduction

The goal of President Harry Truman's 1947 Commission on Higher Education, that the system must provide "the means by which every citizen, youth, and adult, is enabled and encouraged to carry his education, formal and informal, as far as his native capacities permit" is accepted as axiomatic (Boyer Report).

Marketplace demands have presented a crisis for education. Central are appropriateness and access which includes cost and flexibility (Daniels, 1997). The utilization of technology appears to be a means of relief. However, a vehicle not in control is not likely to win the checkered flag for leadership in application.

Sir John Daniels (1997) in a presentation to the American Association for Higher Education asks "Are universities teaching the knowledge and skills that students need? Do our teaching methods match the habits of today's learners? Are universities confident about the quality of what they do? Can the traditional campus model refashion itself for the era of lifelong learning?"

That educators are concerned is evident. Centers such as the University Center for Excellence in Teaching are present on every major university

campus. Each is involved in similar activities. Each is concerned with the suitable implementation of technology as an instructional aid.

Teaching priorities may need to shift. Unquestionably, accommodation for the learner is primary. Every aspect of learner wherewithal must be considered. The totality includes skills and abilities as well as dispositions.

Relevant Applications of Technology

The stage was set in the mid-sixties when S. Postlethwait Purdue University, unveiled the Audio-Tutorial (A-T) method for teaching (S. Postlethwait, J. Novak, and H. Murray, Jr, 1969). From a shoe box with an audio cassette tape and a few visuals such as a twig, the alternative for the professor-directed large-group instructional format more by accident than design developed into an individualized instructional style. The benefits of individualized instruction were cited much earlier by pioneers of programmed instruction, B. F. Skinner (1954) and S. Pressey (1926). We know these to be: on-demand accessibility, self-paced progress, and direct access to assistance when and as needed.

As audio-tutorial instruction at Purdue University was being refined and evangelized throughout the world, Jerry Nisbet, Ball State University, adapted a World War II military aircraft observer training program into an Electronic-Response system for small group instruction (J. Nisbet and R. Olsen, 1973). This system was set up to offer a fast-paced multimedia instructional presentation purposefully interrupted with questions requiring an immediate student response. The table arm of each student chair was outfitted with five choice buttons linked to a console that recorded each response. Scores were maintained as a performance record.

The length of each Electronic-Response system program was limited to accommodate the adult attention span, approximately twenty minutes. After the successful military style of teaching, each instructional unit was written to be compact, fast-paced, and content intensive. Student attention and focus were required throughout.

The E-R system coupled with the Audio-Tutorial format was the state-of-the-art prototype of technological applications in higher education. The underlying concepts of both the Audio-Tutorial method and the Electronic-Response system in conjunction with established learning theory and cognitive style perceptions composed a worthy model for extrapolation in the utilization of today's high-powered electronic technology.

Strategic Systems

Missing from the equation is the operational methodology that imaginatively connects the teaching and learning enterprises and creatively gives life to the curricular body. Without this intangible matrix, a machine is a machine and an electronic device will be an electronic device. Alone, neither is more than the potential of their endowed components.

Systems thinking currently described by P. Senge (1990) as the "fifth discipline" is the embracing organizer that breathes vitality into technologically mediated instruction. It is a conceptual cornerstone for interconnecting the segments of complex interactive situations. Perhaps its origins can be traced back to the British attempt to maximize their World War II operational effort through the judicious utilization of every available resource. The program that evolved was known as "Operations Research." It involved the application of the scientific method and the utilization of an interdisciplinary team of specialists in the selection of means that best served their overall objective.

Later, the British Operations Research program was adapted by the United States Department of Defense for the development of the Polaris missile system (R. Ackoff, S. Gupta, and J. Minas, 1962). The best known of the tools to evolve from the Polaris project was Program Evaluation and Review Technique, PERT. As reported by D. Dyman (1972), according to E. Haga,

> PERT . . . is a powerful management tool for project schedule monitoring and control. The basic element is a

work flow network defining sequential relationships and dependencies of each of the steps . . .

and according J. Garlock,

> PERT is a set of principles, methods, and techniques for planning programs in relation to objectives, interrelating and controlling variables of time and resources, scheduling events and activities, and replanning research or development programs.

PERT did filter from the Department of Defense into other government agencies, industry, and education. In education, its common use was limited to administrative functions. The most ambitious educational analysis project was undertaken in 1967 by a group of specialists representing government, education, community, and industry. The meeting was convened to encourage the communication of ideas, developments, and techniques which could contribute to the advancement of quality and efficiency in the nation's education and training programs. As the project developed, it adopted the name of Annual Review and Information Symposium on the Technology of Training, Learning, and Education or Project ARISTOTLE.

The outcome of the symposium was the establishment of an eight step systems program for the analysis of the instructional process: (1) statement of a need, the problem; (2) identification of objectives, measurable learning goals; (3) determination of constraints required to guide the selection of alternatives; (4) establishment of alternatives, generally a list of potential solutions; (5) selection of the most feasible alternative; (6) implementation of the selected alternative; (7) evaluation of the selected alternative; and (8) modification, an iterative process tending toward perfection.

In this context several versions of systems management for education were developed. Each included the basic elements derived from Project ARISTOTLE. In the plan offered by J. Albracht as reported in D. Dyman (1972), the systems approach involves three major dimensions, student, teacher, and instructional material. The student must be considered in terms

of learning styles and the things (s)he needs to know. The teacher is the most important element of the instructional design because the teacher must have teaching and technological competence, make sure the units are relevant to individuals, and select the best available methods and media to develop the student abilities. The instructional material needs to be scrutinized in terms of time and cost requirements.

Systems Framework for Instructional Design

Taking this into account, in 1970 at Ball State University, PERT was applied in the development of instructional materials. In addition, it was coupled with a second management tool, Critical Path Method (CPM), designed to be a cost effectiveness tool. With that in mind, CPM was used uniquely to evaluate the effectiveness – efficiency relationships of each instructional component. The sequence for the application of systems methods in the design of instructional materials is shown in Figure 1, Systems Framework for Instructional Design.

Needs assessment was the starting point. As stated by J. Bruner (1965), it is essential to have a "clear sense of what has to be attained at later stages to plan the order of learning at earlier stages." To this end, between five and ten students were interviewed each week over three academic quarters. Notes were kept of the dialog to give direction to the pending course content. Patterns of interest were coupled with recognized marketplace needs. These constructs were then integrated into a framework of solid uncompromisable subject area fundamentals both theories and principles.

Instructional design was predicated upon written instructional goals. T. Cyrs and R. Lowenthal (1970) advocate the use of instructional objectives for the benefit of both the student and teacher because the objective indicates exactly what is expected with the completion of the instructional system and it provides the student with assurance that evaluation will reflect acquired skills, knowledge, and concepts. Each instructional goal or objective was intended to provide (1) a benchmark for congruent evaluation and statistical analysis of achievement and (2) a taxonomic index for the

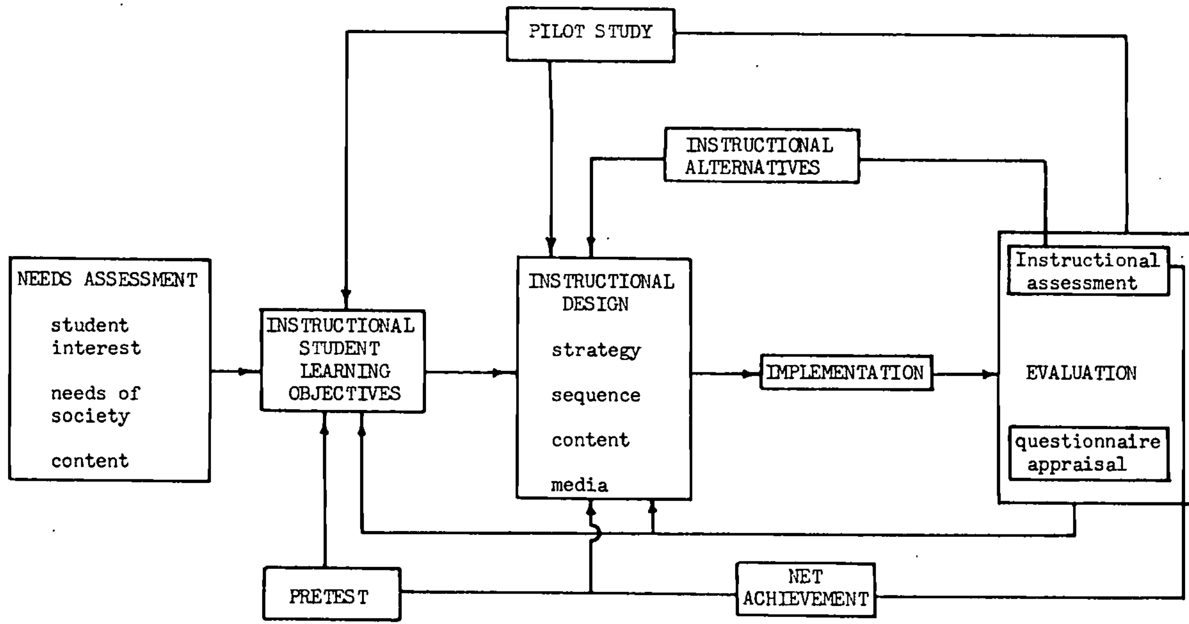

Figure 1. Systems Framework for Instructional Design

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cognitive level of achievement as knowledge, comprehension, application, analysis, synthesis, and evaluation (B. Bloom, 1971).

Learning Theory

The instructional materials were designed according to fundamental learning theory presented by D. Ausubel (1965 and 1968), J. Bruner (1965 and 1967), R. Gagne (1970), and others. A main focus of Ausubel's learning theory is "reception learning" which is concerned with "the psychology of how individuals comprehend, learn, organize, and remember large volumes of meaningful verbal materials" they typically encounter in a classroom situation. Reception learning requires the process of "subsumption" which involves both interaction and inclusion of new knowledge with previously acquired information. Thus, with acquisition, knowledge is subsumed into more inclusive concepts resulting in higher levels of comprehension. The efforts of J. Novak (1964 and 1965) have supported the Ausubelian subsumption theory.

In addition to subsumption, Ausubel's learning theory involves the constructs of "expository organizers," "comparative organizers," and "anchorage." Expository organizers, provided prior to an instructional presentation, prepares the learner's cognitive structure for the reception of new knowledge; comparative organizers are used to integrate existing concepts with similar concepts which remain to be learned; and anchorage involves the addition of new information to existing concepts which serve as nuclei or "anchors." Significant technical teaching skills, "establishing set" and "establishing appropriate frames of reference," appear to accommodate Ausubel's organizer and anchor concepts.

Thus, to substantially improve the educational process, emphasis must be placed upon improving the methodology of subject matter presentation. Students must be prepared for the instructional process and by proper sequencing of instructional materials, new knowledge may be efficiently added to the existing cognitive structure. To be meaningful, a curriculum must be concerned with the systematic presentation of its subject matter.

The principle underlying J. Bruner's theories of instruction and processes for education is that any subject can be taught to any individual in some honest form. However, the challenge facing the instructional process is to properly devise learning sequences which facilitate the educational process. Since the mind can effectively deal with only a few operations at a single time, disorganized information will probably effect learner frustration and confusion.

A series of episodes involving acquisition, transformation, and evaluation are usually required if learning is to occur. Acquisition of new information occurs as an alteration or replacement of what has been known; transformation is the process of manipulating new knowledge to make it fit new tasks; and evaluation is checking the adequacy of the transformed acquisition.

Central to the instructional process must be the provision of appropriate aids and dialogues for the establishment of more effective conceptual hierarchies. The instructional process must be concerned with the formulation of environments which optimize learning.

For R. Gagne, learning is more than just a natural phenomenon that happens as a result of development. It is to a large extent dependent upon events in the environment which occur under precise conditions which can be objectively described. Observations of learning situations and performance outcomes led to the identification of eight kinds of learning ranging from "signal learning," the least complex, to "problem solving," requiring complex internal events. The various classes of learning, each with specific conditions that effect precise performance changes, imply a hierarchy. To bring about effective and efficient learning, good instruction should be carefully organized to provide the conditions which are required for the achievement of a particular learning level. Good instruction is planned to provide for the specific conditions applicable to the task being learned, learner capabilities, learning prerequisites, and learning structure.

From J. Piaget (1970 and 1971) we recognize that the learner progresses through stages of operational capability. The domain of the preadolescent is concrete operations. The individual learns in association with tangible

objects and learning is constructed from unsophisticated and perception-limited spatial observations. On the other hand, adult learning proceeds from a formal operations level. Knowledge can be acquired outside of the framework of objects. Adult abilities reside within the higher order capacity of the abstract and intangible.

While the adult learning capability is assumed, J. Renner and W. Paske (1977and 1979) reported that many college level students may be deprived. Their operational capacity is restricted within the concrete domain. Thus, the transfer of information as in a classroom environment that commonly requires abstract thinking is seriously limited. Renner and Paske did find that learning could be improved with the application of investigative and guided discovery activities. In addition, through the application of these instructional strategies, learners were enabled in the transition to formal operations. Independently, D. Kolb (1983) developed a learning style inventory which can provide insight into the operational zone of individuals.

Construction of Instructional Systems

With the framework of content, statement of objectives, and description of the student instructional state, the instructional process can be carried out (Glaser, 1966). The principal task involved in developing instructional strategies is relating the best combination of media and methods (Briggs, 1970). The key to the application of strategic systems in instructional design is iteration (Wooton, 1971), the process of ongoing evaluation, revision, and implementation leading to progressive refinement of the system.

Though Glaser (1966) indicated that the instructional designer or educational technologist is a specialist who "hardly exists in our society," the application of strategic methods including immutable learning theory and recognized teaching methods and techniques did lead the way in a pioneering effort in the development of the science of instructional design. Guided discovery, structured interaction, graphic illustrations and sequences (tables, charts, sketches, diagrams, photos, and film loops), selected

readings, simulations, examination of living and preserved specimens, investigative activities, problem solving, linear and branched programmed instruction sections, and record keeping were among various strategies that were integrated and linearly configured to mediate knowledge, comprehension, and application levels of learning in the non science major biology course at Ball State University.

In support of the learning activity, a Learning Guide was developed to provide for attending behavior and interaction. The purposeful design was set in a modified programmed instruction format of True-False, Matching, Matching, and Fill-in-the-Blank, type questions. Quick responses, reliability, and consistency were the hallmarks. Completed with student responses, it provided everything a learner needed in review and preparation for examinations.

Overview of Findings

Evaluation of the Ball State University instruction design project was encouraging. Mean cognitive achievement at the level of knowledge was 79.2%; comprehension, 79.5%; and application, 62.9%. Mean ratings for relevance, practical value, and interest were: 40.3%, 37.7%, and 33.3%, respectively at the very high level and 50.7%, 50.0% and 45.7% respectively at the high level.

In a subsequent National Science Foundation sponsored study based upon the research work at Ball State University, students were able to comparatively progress through more content material at a significantly higher (0.05 to 0.03) level of achievement. Supporting data was provided from three semester long (sixteen week) freshman and sophomore college level general biology courses. (Dyman, 1982)

Summary, Conclusions, and Recommendations

To competently design instruction, we have to understand that our success is not in the vehicle but in what we do to get where we want to be precisely

how we want it to be. It requires thoughtfulness. We have to ask ourselves questions in behalf of the learner. Planning, organizing, designing, implementing, and evaluating learning segments and outcomes as well as making continued revisions to assure ongoing relevancy and practicality are the primary tasks of the instructional designer. In totality, they represent an instructional / learning management system.

The application of systems strategies is an invaluable tool for the management of instructional design. This approach provides the format for the assessment of learning needs, the formulation and implementation of instructional sequences, and the evaluation of effectiveness. Overall, the approach presumes ongoing efforts for improvement.

From studies at Ball State University, learning can be facilitated as well or better through the employment of technological resources than through commonplace group-paced teacher-directed classroom activities. Technology is an important means of transferring information and providing for learning at least at the knowledge, comprehension, and application levels leading to problem solving. Furthermore, the need for direct teacher contact appears to be necessary only when the student experiences learning difficult. A teacher's comments, confirmation, correction, and encouragement, coupled with a strategically designed instructional system provide that combination of factors resulting in a meaningful environment for learning. The quality of teacher-learner contact appears to be more significant than the quantity of that contact. (Dyman, 1972).

Several avenues of continued research remain opened. Such research should lead to the development of more scientifically designed learning systems. Various instructional strategies and the elements therein should be analyzed for the unique contributions in teaching effectiveness and learning efficiency; in the mediation of learning at specific cognitive levels such as knowledge, comprehension, or application; and in the acquisition of thinking and problem solving skills.

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